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Claim Rejections – 35 U.S.C. § 103(a)

Claims 1-47 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,373,112 (“Murthy”) in view of U.S. Patent No. 6,319,782 (“Nakabayashi”) and U.S. 5,879,970 (“Shiota”). Applicants respectfully traverse these rejections.

Applicants respectfully submit that the Office has not established a *prima facie* case of obviousness. In particular, for each of Claims 1-47, the Office has failed to meet at least one of the three criteria for establishing a *prima facie* case. See M.P.E.P. § 2143. For the convenience of the Office, the rejections of Claims 1-47 are discussed below in sections corresponding to each of independent Claims 1, 20 and 33.

Claims 1-19 and 40-41

Claim 1 recites a combination of limitations including depositing a silicon-containing seed layer over the high dielectric constant material under seed phase conditions selected to minimize hydrogen reduction of the high dielectric constant material. As discussed in the specification at, e.g., paragraphs [0020] to [0021], the inventors have found that traditional methods of depositing silicon-containing materials, such as polysilicon and poly-SiGe, over high k dielectrics tend to result in poor electrical performance of resultant devices. One possible reason for this poor performance identified by the inventors is the reduction of oxide.

The specification describes processes for depositing electrode materials, preferably silicon-containing layers, over high k materials while minimizing reduction of the high k materials. As discussed in the specification at, e.g., paragraph [0077], minimizing reduction preferably includes one or more of: minimizing hydrogen content in the process gases; minimizing process temperature to avoid hydrogen diffusion to the high k material during deposition; and minimizing silicon source gas partial pressure, thereby decreasing both hydrogen content and diffusion.

Applicants respectfully submit that the claimed invention, as defined by the combination of limitations recited in Claim 1, is neither taught nor suggested by the cited references. Likewise, dependent Claims 2-19 and 40-41 recite a number of additional limitations that, in combination with the limitations set forth in the claims from which they depend, define additional inventions that are neither taught nor suggested by the cited references.

The Office characterizes the primary reference, Murthy, as follows:

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Murthy discloses the limitations of claims 1-47:
depositing a silicon-containing seed layer (106, fig. 2) over the high dielectric constant material (104, fig. 2) under seed phase conditions (col. 2, lns. 29-38); and
depositing a silicon-containing bulk layer (108, fig. 2) over the seed layer under bulk phase conditions, the bulk phase conditions selected to result in a higher deposition rate than the seed phase conditions (col. 4, ln. 41 – col. [5], line 9).

Office Action at 2. Applicants note that Claims 1-47 were not rejected under 35 U.S.C. § 102, the Office apparently recognizing that none of the cited references disclose all of the limitations recited in each of Claims 1-47. With respect to Claims 1-19 and 40-41, Applicants note that the Office does not allege that Murthy discloses seed phase conditions “selected to minimize hydrogen reduction of the high dielectric constant material” as recited in Claim 1, and thus correctly recognizes that Murthy does not disclose this limitation. Nor does the Office allege that Murthy discloses various limitations recited in independent Claims 20 and 33, as well as dependent Claims 2-19, 21-32 and 34-47, thus correctly recognizing that Murthy does not disclose these limitations either.

The Office Action continues by stating:

Murthy discloses the claimed limitations, as described above, except for the limitations disclosed below by Nakabayashi and Shiota:

Nakabayashi discloses:

wherein silane includes higher order silane gas;

wherein the seed phase is less than 500 Å/min and the deposition rate for of [sic] the bulk phase is greater than 500 Å/min (col. 10, ln. 44 – col. 11, ln. 31);

Shiota discloses:

using a non-hydrogen carrier gas (col. 1, lns. 20-40); and

Therefore one of ordinary skill would have combined the limitations disclosed in Nakabayashi and Shiota with Murthy, because Murthy does not explicitly state some of the process conditions that are claimed. Also, Murthy explicitly discloses “other oxides such as for example Hafnium oxides,[”] and the specification does not disclose a distinctive difference between the materials listed in the group of high dielectric materials. Therefore, because Murthy does disclose one in the group it would have been obvious to one of ordinary skill in the art at the time of the invention to use the other materials in the group.

Office Action at 2-3. Applicants respectfully submit that none of the cited references recognize the possibility that reduction of the high k material is a problem during gate electrode deposition, let alone provide a solution to the problem that involves conditions selected to minimize hydrogen reduction of the high dielectric constant material as claimed. Murthy discloses the use

of a seed phase in order to reduce the roughness of a subsequently deposited SiGe layer, *see* Murthy at column 3, lines 57-60. There is no teaching or suggestion in the art to replace or modify this seed phase to minimize hydrogen reduction of a high k gate dielectric prior to the bulk deposition.

Murthy itself discloses the use of hydrogen as a carrier gas during seed layer deposition and fails to suggest that such use should be minimized. The Office appears to realize that the cited references fail to recognize the reduction problem and that Murthy fails to teach minimization of hydrogen, but alludes to the possibility of a different motivation. The Office states that Nakabayashi “discloses using Chlorine as a carrier gas, to strip away unwanted oxide that is formed,” Office Action at 3, and thus appears to contend that a desire to remove oxide would have motivated one skilled in the art to modify Murthy by replacing the hydrogen carrier gas with chlorine. However, Murthy uses a gate oxide 104 as a substrate for the deposition of the Si layer 106, *see* Murthy at column 4, lines 52-56. Since Murthy desires the presence of the gate oxide, one skilled in the art would not be motivated by Nakabayashi to replace the hydrogen of Murthy with chlorine because of the likelihood of undesirably stripping away the gate oxide.

Applicants respectfully submit that Shiota teaches away from minimizing the use of hydrogen by disclosing that the presence of hydrogen is desirable for obtaining a high quality layer: “When hydrogen was used as the dilution gas, crystal defects at the grain boundaries were cured by the hydrogen. Thus, the hydrogen achieved a high quality polycrystalline silicon-germanium alloy layer.” Shiota at column 4, lines 44-47. Rather than establishing a motivation to combine, Shiota teaches away from the instantly claimed combinations of limitations. “It is improper to combine references where the references teach away from their combination.” M.P.E.P. §2145(X)(D)(2).

In addition, the Office has not indicated why one skilled in the art would have selected a high dielectric constant material in the first place from among the various possible materials disclosed by Murthy. Murthy discloses a number of dielectric materials, and indicates that because deposition of the Si layer “is compatible with many dielectric structures and compositions, further details of gate dielectric formation are omitted here.” Murthy at column 4, lines 49-52. The Office has not indicated how the secondary references would have motivated one skilled in the art to select a high dielectric constant material from among the various possibilities disclosed in Murthy.

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Applicants respectfully submit that the statement by the Office that “one of ordinary skill would have combined the limitations disclosed in Nakabayashi and Shiota with Murthy, because Murthy does not explicitly state some of the process conditions that are claimed,” Office Action at 3 (emphasis added), indicates that this § 103(a) rejection is based on the use of impermissible hindsight. One skilled in the art could not have known that Murthy “does not explicitly state some of the process conditions that are claimed” without hindsight knowledge of the claims, and thus could not have been motivated in the manner suggested by the Office.

Applicants respectfully submit that the Office has not established a *prima facie* case of obviousness because there is no motivation to modify Murthy to meet the instant claims. See M.P.E.P. § 2143. Therefore, because a *prima facie* case of obviousness has not been established, Applicants respectfully request reconsideration and withdrawal of the rejection of Claims 1-19 and 40-41 under 35 U.S.C. §103(a) as being unpatentable over Murthy, further in view of Nakabayashi and Shiota.

Claims 20-32 and 42-44

Claim 20 is directed to a method of forming a structure in an integrated circuit that involves forming a layer of high dielectric constant material and depositing an electrode material over the layer of high dielectric constant material by flowing a higher order silane. Applicants respectfully submit that the claimed invention, as defined by the recited combination of limitations, is neither taught nor suggested by the cited references. Likewise, dependent Claims 21-32 and 42-44 recite a number of additional limitations that, in combination with the limitations set forth in the claims from which they depend, define additional inventions that are neither taught nor suggested by the cited references.

The aforementioned Office Action states that “Murthy talks of the general conditions of how to form a seed layer and give an example of using silane as the main gas.” Office Action at 3. Applicants respectfully disagree. Murthy specifically refers to the use of silane itself, SiH₄, to deposit the seed layer, not a higher order silane, *see* Murthy column 4, lines 52-56. The Office recognizes that Murthy does not teach or suggest the use of a higher order silane, but points to Nakabayashi’s disclosure at column 10, lines 60-65 of “using either silane or disilane” as proof that “one of ordinary skill in the art uses the gases interchangeably.” Office Action at 4. However, the alleged interchangeability disclosed in Nakabayashi is expressly for the purpose of

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“growing the single-crystal silicon films 307,” *see* Nakabayashi at column 10, line 60 (emphasis added), not for the purpose of depositing a “nanocrystalline Si seed film” as disclosed in Murthy. Those skilled in the art understand that silicon source gases that are interchangeable for the deposition of one type of film are not necessarily interchangeable for the deposition of another type of film. Thus, Nakabayashi does not support the contention by the Office that one skilled in the art would have considered silane and disilane to be interchangeable for the deposition of the “nanocrystalline Si seed film” disclosed in Murthy.

In addition, one skilled in the art would not have been motivated to modify Murthy by replacing silane with disilane because Nakabayashi discloses that the use of disilane results in the “undesirable” formation of amorphous silicon oxide, *see* Nakabayashi at column 6, lines 61-64; column 7, lines 13-16; column 8, lines 53-56; column 9, lines 6-9; etc. Nakabayashi discloses the use of chlorine to remove the undesired oxide, but, as discussed above, one skilled in the art would likely view such use as undesirable because it would also strip away the gate oxide over which Murthy is depositing his seed layer. Nor does Shiota provide a motivation to modify Murthy in the manner suggested by the Office.

Applicants respectfully submit that the Office has not established a *prima facie* case of obviousness because there is no motivation to modify Murthy to meet the instant claims. *See* M.P.E.P. § 2143. Therefore, Applicants respectfully request reconsideration and withdrawal of the rejection of Claims 20-32 and 42-44 under 35 U.S.C. §103(a) as being unpatentable over Murthy, further in view of Nakabayashi and Shiota.

Claims 33-39 and 45-47

Claim 33 is directed to a method of forming a silicon-containing material over a high dielectric constant material that involves loading a substrate into a single-substrate reaction chamber and depositing a silicon-containing layer over a high dielectric constant layer on the substrate without flowing hydrogen. Applicants respectfully submit that the claimed invention, as defined by the recited combination of limitations, is neither taught nor suggested by the cited references. Likewise, dependent Claims 34-39 and 45-47 recite a number of additional limitations that, in combination with the limitations set forth in the claims from which they depend, define additional inventions that are neither taught nor suggested by the cited references.

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As discussed above, Murthy specifically discloses the use of hydrogen as the carrier gas during seed layer deposition (*see* column 4, lines 52-56) and thus fails to teach or suggest the instantly recited "without flowing hydrogen" limitation in combination with the other recited limitations. Nakabayashi fails to teach or suggest excluding hydrogen from Murthy's process in the manner recited in the claimed combinations, and Shiota teaches away from such exclusion, as discussed above.

In addition, Applicants respectfully point out that the Office has not even alleged that Murthy discloses loading a substrate into a single-substrate reaction chamber as claimed, nor that either of the secondary references teach or suggest modifying Murthy to meet this limitation in combination with the other recited limitations.

Applicants respectfully submit that the Office has not established a *prima facie* case of obviousness because there is no motivation to modify Murthy to meet the instant claims. *See* M.P.E.P. § 2143. Therefore, Applicants respectfully request reconsideration and withdrawal of the rejection of Claims 33-39 and 45-47 under 35 U.S.C. §103(a) as being unpatentable over Murthy, further in view of Nakabayashi and Shiota.

Conclusion

Applicants respectfully submit that the instant application is in condition for allowance, early notification of which would be appreciated. The Office is respectfully invited to contact Applicants' representative at the telephone number provided below with any questions regarding this application.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

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By: Joseph J. Mallon
Joseph J. Mallon
Registration No. 39,287
Attorney of Record
Customer No. 20,995
(619) 235-8550